Interdisciplinary course of

# Design and Robotics

10° edition, 2022

Project:
**Jell-E**


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# Index

# Abstract

We are now at the age of micro breakthroughs. The creations that are seeing light aren't ones that are shifting the fabric of our existence dramatically anymore. We look around us and we see electric vehicles getting more efficient, space travel becoming faster and further reaching, research becoming more accessible, and many more things improving.
In this project, we plan to design what we can call an improvement in the way of life of those who really need it. It will be a shift in their lives.
The time it takes us to form our identity is nothing compared to the time we spend defending it. The harder we work to form it, the harder it becomes to incorporate it in a world full of diversity and adversity.
It comes as no surprise for us that we focused on kids with social and emotional difficulties. We figured that we can design an element that kids can host on their shoulders that would not only be an extension of their limbs but also a friend when needed. A listening, sensing friend that responds to a child's stimulus and acts accordingly to divert a child's anxiety and allow others to understand the state of mind they are going through.
The robotic element is designed to exaggerate the child's feeling and show it to the world around them. This will help all that are in close proximity to the child understand and cope with the feelings they are experiencing.
The robotic tentacle, as it has become, would be flexible and give much needed feedback to all the people that form the ecosystem around it. It moves by means of motors and wires and its adapter, that allows it to be fixed on the shoulder without annoying the host, is made of soft material encasing a rigid skeleton that gives it the firmness needed to remain in place through usage.
Its operations relate to the sensed pressure and sounds that are detected by secondary tentacles that detect sound near the mouth as well as touch at the hand. The message is sent to a processor that runs an algorithm that gives the order to the tentacle to react.
The result is an agile limb that extends from the body and interacts with the surroundings to clear tension and anxiety that arise from day to day encounters.

# Phase 1: Discover

In this phase we start to organise ourselves, the team management, the tools we will use to communicate and we start to develop a common language.

## Team Organisation

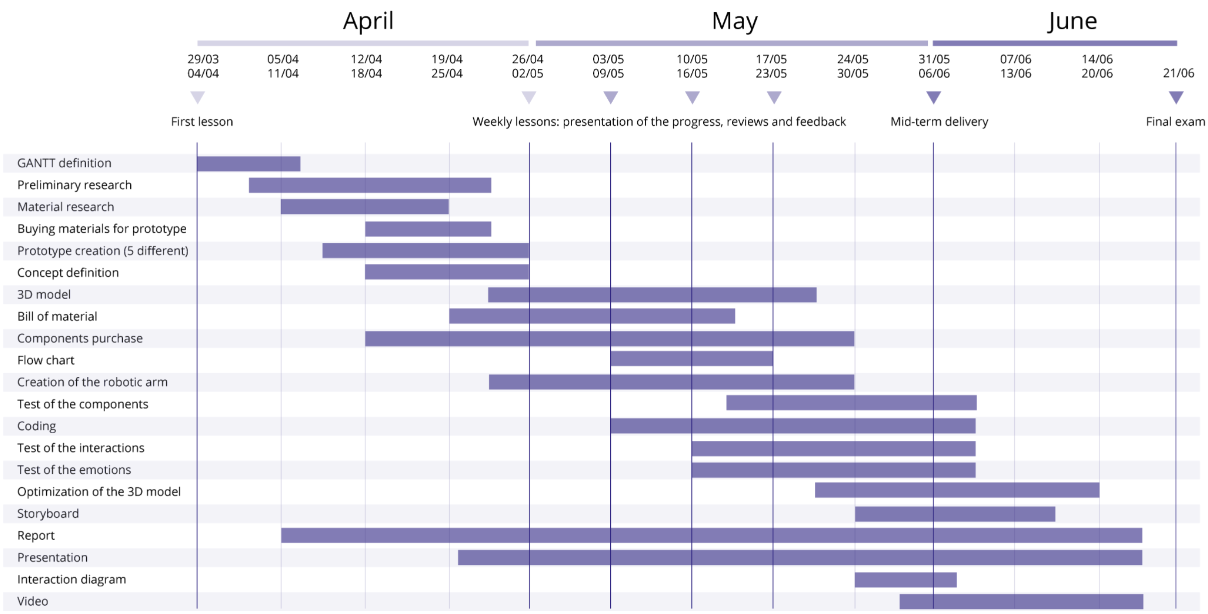
Our team is composed of:

Giorgio Brugali, II year of MSc in Computer Science & Engineering
Alessandro Caruso, II year of MSc in Design & Engineering
Greta Corti, II year of MSc in Computer Science & Engineering
Leonardo Gargani, II year of MSc in Computer Science & Engineering
Yeran Liu, II year of MSc in Interior Design

The team leader is **Alessandro Caruso**. His responsibility is focused on building the team, spreading the tasks and communicating the project. Our goals are divided between the two designers, whose focus is related to the shape of printed components, flux of interactions, graphics, and presentations, and the three engineers, who manage the robotic arm and the inner hardware components, that allow the robot to function and be responsive.

## Project Management

Our team plans to solve the tasks according to the following GANTT drafted during the course and updated during the weeks according to the flux of the work.




Gantt available also as PDF, click here or over the picture.

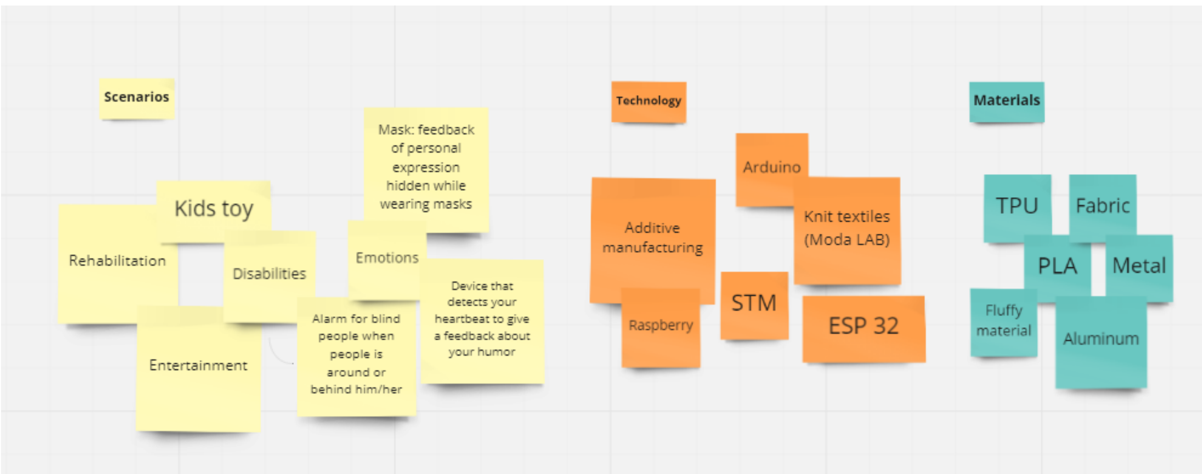
This GANTT is a final version of the workflow we carried out, which was not crystal clear at the beginning of the course. Indeed the first GANTT has been developed after a few weeks of work, once all the components of the group agreed on its functionality and utility since we started to plan the following weeks in a more strict and rational way.

The coordination of the group was managed by using common tools such as Telegram as the main communication channel of the team, Google Drive as the official tool to storage presentations, bills, pictures, videos and graphics. We also used a Miro board to gather information, making the remote work smooth and GitHub to store all our internal files.

# Research

As is the case for any proper research, we started first by collecting literature concerned with our topic of soft robots. We then started combing through the literature as we focused our attention towards wearable robotic elements that could be connected to the human body to become extensions of the host. In the definition of a parasitic element, our limb is to not only ride on the body but also influence it and its behaviour.

In specific, we started off by splitting our focus over three categories that we envisioned would become the pillars of our design process; we looked into scenarios, technology, and materials. For a while we thought that that would be the optimal approach. After collecting data for every category, we presented our work to acquire feedback from our professors. We were quickly advised to take a step back and refocus our attention towards one of the many subcategories that seemed to begin to express themselves boldly under our previous titles. and under the title "scenarios", the sub-title "kids toys" started to sound more and more as a viable option.




Miro board: brainstorming available here.

However, as we looked into it further, we realised the potential that we felt we were misplacing. We then decided to combine this title with one that we think more and more designers should keep in mind during any design project, and that title is "disabilities and personal difficulties".

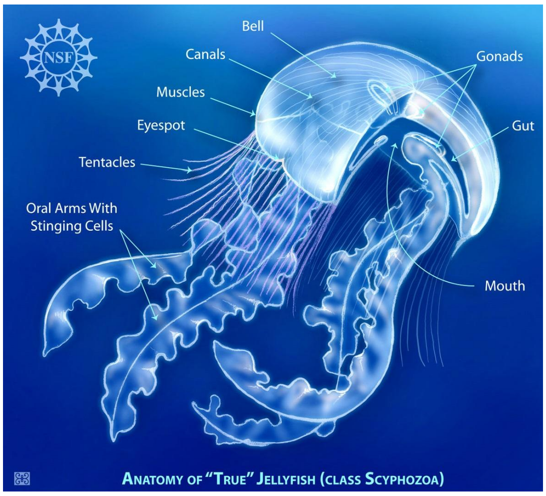
## Kids: Emotions, Difficulties, and Psychology

The more we brainstormed around this combination of topics, the more we realised that we, as designers and engineers, can be offering much more than "the bare minimum" and "what's necessary" for kids with difficulties. For a minute, we asked ourselves, what can we offer kids with social difficulties, kids that are not as social as those around them or as social as their age permits. Kids must not be left to fight their intricate personalities that are in a constant state of construction as they take from the world around them and project it into themselves and onto the world around them.

That's when we realised everything was fitting together. To create a parasitic element that would be not only fun and helpful but also sensitised in the sense that it takes from the host body and projects onto the world just as it takes from the world and introduces it into the host. We started discussing the idea of imaginary friends and things of that sort when we were young; we gave life to inanimate objects, sometimes to things that were not there, giving it its role in our life. We focused on a very critical title "Transitional objects" which are "chosen possessions that offer security and comfort to a child. They're often soft and huggable items, such as teddy bears and blankets, that are used to soothe during a transitional phase." It is difficult to assume many things about kids with social difficulties, so we focused our research one final time to include papers written about child psychology. We were pleased to know as well that many universities have already integrated this into their design programs.

## Animals inspiration

The Jellyfish does not have blood, bones, or a heart. Yet it houses a nervous system with receptors that detect light, vibrations, and chemicals in the water. This has allowed this animal to live for millions of years roaming the oceans, evolving, and progressing. Thus, the jellyfish, although lacking key animal-like characteristics, is a prospering and successful class of the animal kingdom. Showing us that adaptation can come from adversity.




Scheme of jellyfish anatomy.

We were quite fascinated by this creature and we studied it as we progressed onwards with our developing project. The jellyfish was studied for more than its existential face. We were inspired by its flexibility and its skin that is mostly translucent. Again, this feature allows a soft looking creature to become a predator in its context, making sure it gets a chance to express its existence within its surroundings.

## Robot development

From the start, we agreed that the robotic element will be an aid and not a distraction. It cannot over-interfere with the host's activities in reception as well as communication.

We started researching with that in mind. We picked up on several key ideas. Firstly, we wanted the robotic entity's receptors to be close to the host's human receptors. Our focus yielded several results of robotic elements that were attached to the upper half of the human body. Anatomically, the shoulders provide flat support and this was significant seeing that we did not want our design to squeeze or bother the host. This was also reflected in our choice of materials as we progressed, as you shall find discussed further in the functionality of our design.

The design had to include, as mentioned earlier, receptive as well as motor abilities. We started looking for precedents and concepts that would prevent our young host from looking like a telecommunications tower. We decided that convenience in this case had to come from combining receptive and responding nodes in one form of geometry so the host doesn't feel overpowered by the guest feature. For that, we needed to move away from any movement that would be greatly similar to the human arm and hand. We reflected towards the tentacle and decided that it would be interesting for several reasons; its difference in motion from the human arm along with the sense of nuance that it introduced to the host - if we may, we brought up the idea of superhero abilities.

Having said that, we started designing the tentacle with receptors and responders included within it.
There had to exist a brain as well as motor center for the tentacle. This head would hold the LEDs that would light up with respect to all reception and response activities. From the head is to extend two secondary tentacles that help the form act more as a parasitic element, taking from the body and giving back. The first would flow around the neck and around the arm and would allow the user to squeeze it. The second would rest close to the mouth to detect the user's voice, its volume, and its pitch.

# Additive Manufacturing

Most of the work carried out in terms of 3D printed components has been managed by the team components, both for what regards the slicing (managed by Ultimaker Cura) and and its settings (layrs; temperatures; materials, such as PLA and PETG…).

# Phase 2: Define

The second development phase is defined by a first approach to a schematization of the interaction designed for our wearable robots through a simple diagram, further detailed later on, transforming it into a flowchart and a storyboard, able to communicate both logically and visually the goals and aims of the product.

## Interactions and emotions

The scope of the robot is defined by three main groups of detection, translated in a second moment into interactions and emotions shown: pressure, sound and movement detection. These three inputs are received by three different sensors: an off-the-shelf pressure sensor, made by aluminium foil, a microphone and an ultrasonic sensor.

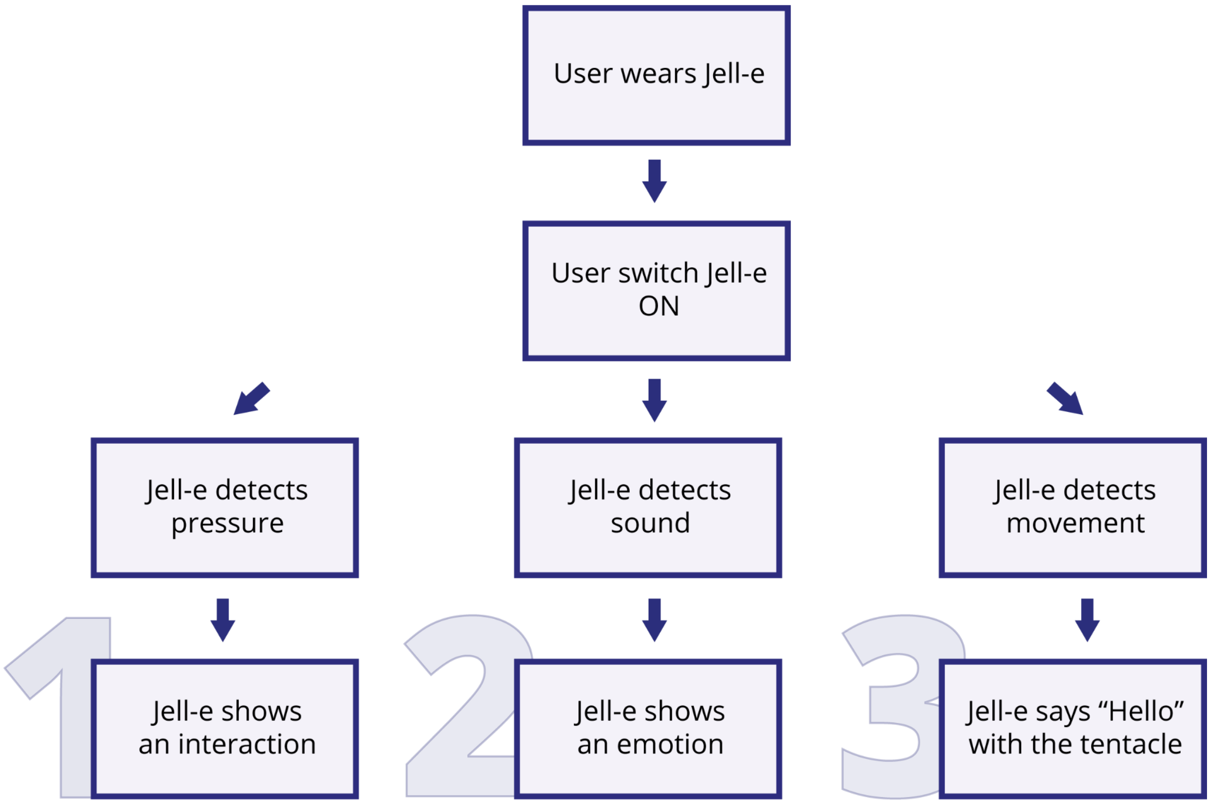


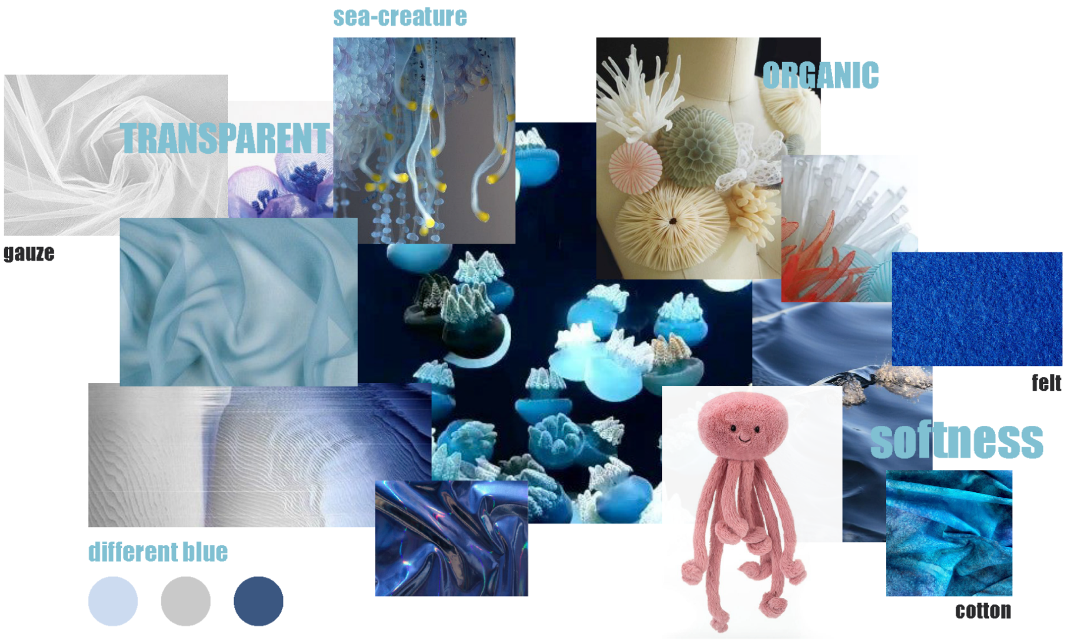

Diagram of interaction, available also as PDF here or clicking on the picture.

The scheme above shows the order of the detection and the interaction the robot aims to have as a final result, following a specific flow of thinking.

# Functionalities

## Fabric

A very important part of our process was the material to be used. Lightness had to be always in mind as well as softness of texture. We could not afford to be a source of annoyance or hindrance for our host. The adapter for the human shoulder would be the point of attachment between the tentacle and the host body, thus it had to be soft yet firm. With that in mind, we added a metallic skeleton within the fabric. The skeleton was housed inside a layer of soft plush material that would distribute the pressure of the adapter onto a bigger surface area of the shoulder.




Moodboard and color palette of the initial stage of development.

A mood board was also formulated to display the materials that could be used depicting colors, folds, and different modes of usage. Based on the literature, the color blue was found to be most calming. In terms of availability, several vendors assured us that the specific material we chose for its reflective appearance along with the color we picked was almost always available all around the world.

We do not mind the color being changed to another if the host finds it distracting, unappealing, or simply not personal enough.

## Touch and pressure detection

As mentioned before, a secondary tentacle would flow around the arm and allow the user to squeeze on it. The frequency as well as the period of the squeeze is sensed and the information is conveyed to the processing center located on the shoulder. Different pressure frequencies and durations are matched with different responses by the main tentacle.

The three different frequencies at which the tentacle responds are triggered at three levels: One squeeze, two squeezes, and one long squeeze. These intercepted signals are met with an inferred emotion and the tentacle changes position and movement speed accordingly. This is also accompanied by the lighting of the LEDs signalling detection and response.

## Sound detection

Another secondary tentacle, as mentioned before, flows above the chest and rests close to the mouth to detect sounds. This receptor measures sound volume and according to the intercepted volume, the tentacle, here as well, responds with a respective speed.

There are two levels of sound volume that are detected with the first being normal conversation volume and the other being a sound higher than that depending on the measured average volume. Measuring the averages on a time-line allows us to remain accurate in the sense that normal conversation sound volume differs based on the location (school, library, beach, car, home…).

## Movement detection

Another interaction designed and placed at the height of the eyes is the movement detection that happens through the ultrasonic sensor, which recognizes whether anyone moves the hand in front of it doing the “hello” movement. When recognised the robot acts consequently, improving the interaction side that the kid wants to have with third people.

## Tentacle movement mechanism

As is the case of the animal body, the brain signals an action and it is executed by means of motor neurons that extend all the way through the body until the last tip of it.

We decided to use motors that would pull our tentacle via strings along its axes. Pivoting two levers on the tip of the motors allowed us to use two motors instead of four to move the entire tentacle in all directions by pulling on it along the two axes. The motor’s rotation pulled on the string that passed through rings along the stem of the tentacle and attached to its tip. This forces the tentacle to collapse in the direction of the force. Pulling on two consecutive strings of the arrangement would force the tentacle to move in the direction of the bisector of the angle formed by the two axes.

We would add a third motor that would be responsible only for the movement of the tip of our tentacle. The aforementioned strings and wires gave us the full range of mobility that we needed for this project.

## Flowchart

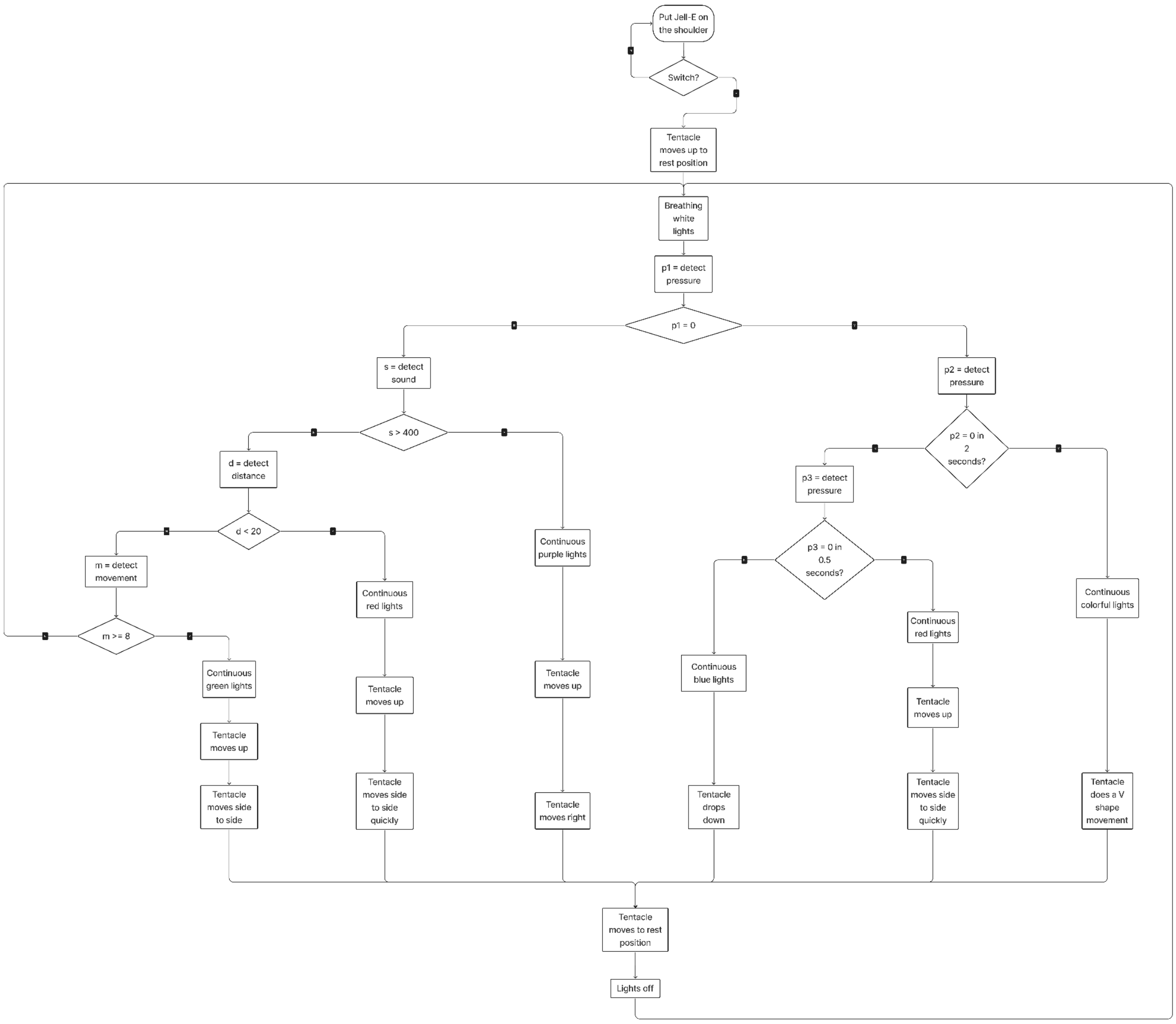
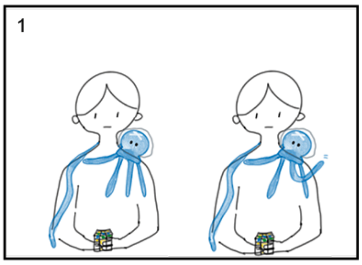


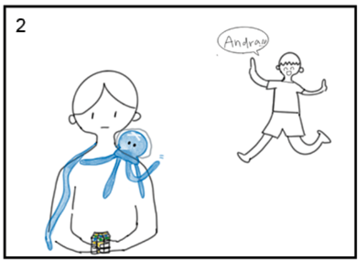

Diagram of the flowchart, available also as PDF here or on FIGMA, clicking here.

All the previous features are explained and translated into a logic scheme, where every single action and detection is explained according to the order of the flux with which the robot has been coded.

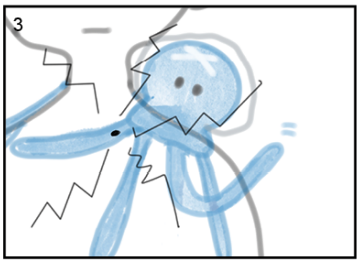
# Storyboard



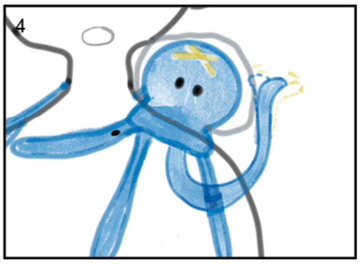

Andrea is a 9 years old boy. He is playing alone with Jell-e on the shoulder. Jell-e is alive with some random movements.



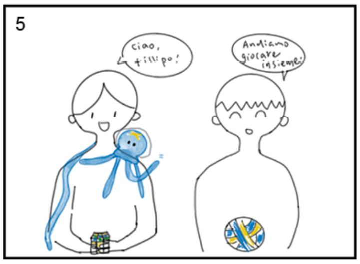

Now a friend of Andrea comes and calls his name from a distance.



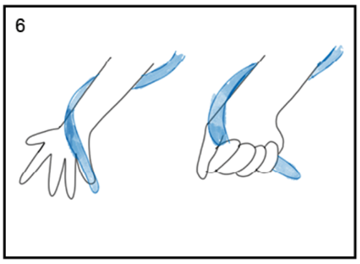

Jell-e has a microphone sensor on the tentacle, it picks up the sound and analysis the db.




Jell-e acts curious, yellow light on and machenical tentacle rises up with random movement, looks like finding the sound.




Fillipo comes close to Andrea, and they begin to talk. Fillipo invites Andrea to play volleyball together with him.




Andrea feels happy about the invitation, he holds the control tentacle and squeezes one time.


Jell-e reacts to the squeeze showing happy, with colorful led shining on the head and tentacle moves quickly from side to side like dog tail.

## Electronics

Once we defined which features and gestures the robot implements, we defined which electronic devices were needed for our robot.
As actuators, we selected two high torque servo motors, used for control of the tentacle along the x and y axis, and a high speed servo motors for the tip since this part is shorter and requires less torque than the rest of the tentacle. The last actuator we selected was the addressable led strip, used to make the robot more expressive.
In order to perceive the interaction with another person, we use an ultrasonic sensor, a microphone and a touch sensor.
We chose an HCSR04 ultrasonic sensor to sense whether someone is too near to the robot or if the person in front of the robot is waving at him or not.
For the sound detection we used an electret microphone; firstly, we tried to make our own amplifier, using a BJT amplifier, but we encountered many problems, and it was very unstable, so after some test we chose to discard it and use an electret microphone with a built-in amplifier. We know that an electret microphone is not a high quality microphone, but it is enough for the goals we want to achieve.
For the capacitive sensor,we opted to simply use a hand-crafted sensor using simply a wire connected to an aluminium foil.
For the microcontroller we opted for using an ESP32 AZDelivery which is small, low-power consumption and so optimal for our project.
Since the robot will be worn and it has to be as light as possible, for the power supply we opted to use a 1700 mAh lipo battery which is small and compact and can provide alimentation to both our microcontroller and motors. The battery is not directly connected to the devices that it has to supply, we also use two step-down transformers in order to give the proper voltage to our devices.

## Coding

During the define phase we wrote the code to test each electronic component independently in order to better understand their behaviour because sensors like microphone and the capacitive one, no one of us had used before this project.
Even if we used an ESP we programmed it with the Arduino library since the board is compatible with it.
Using the standard “Servo.h” library of Arduino, we noticed that it was not easy to obtain the smooth movement of the tentacle, therefore after some online research we selected the “Servoeasing” library, which has a more sophisticated control of our servos.
As already mentioned in the chapter before, the microphone is a very low quality device and affected by a lot of noise. In order to be able to detect loud noises and people speaking we decided to implement a moving average of the microphone readings and instead of directly measuring the value sensed, we decided to use the deviation from the mean to decide whether and which action to do; this strategy improved the quality of the measurement a lot.

# Structure

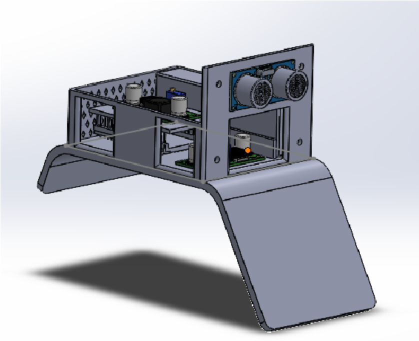
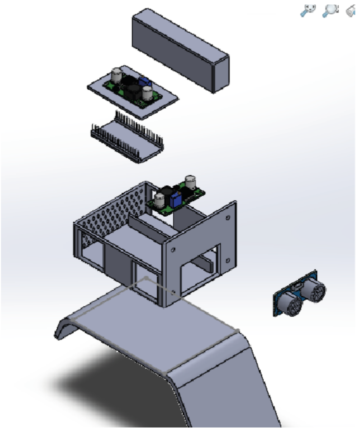
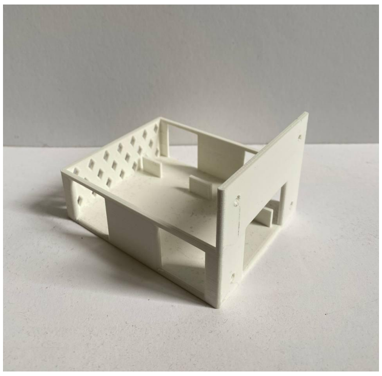
## Robotic tentacle

During this phase we began to design a robotic tentacle that was able to move in 3d space so that it would be as realistic and expressive as possible.
We did some online research and we found different existing models, but they were not suitable for our case because some models used materials that were hard to work with, others required a space that was too large for our robot, others exploited only 2 dimensions movements, and others were very fragile. Not finding the correct model, we decided to design our own tentacle: we started by using a flexible pipe as the core but it made the tentacle badly bend in a single spot, thus we substituted the pipe with a 3d printed structure. We connected two by two the 3d printed pieces with rubber bands to allow the tentacle to bend all together; however, we decided to avoid using them because they have a tendency to deteriorate over time, therefore we used only fishing line, two wires per axis of movement.


First design solutions found for the tentacle (flexible silicone pipe, 3D printed parts and rubber band)

## Box of components

The general idea is to have all the components, except for what regards the robotic arm, inside a off-the-shell box, specifically designed to fit all the parts and being, at the same time, as small as possible, to be able to be stabilised on the kid's shoulder. The first design takes into consideration the creation of a higher front wall to fit the ultrasonic sensor, which will play the role of the eyes of the jellyfish. The following image shows a first attempt to create a functional box.

Assembly and exploded view of the components from Solidworks.

## Shape

The shape of the robot is divided into three o main parts: the base, also considered as an adapter for the shoulder; the head, which will be the main cover of the internal components, and the tentacles.

The first goal was to define and sketch the first general design of the whole jellyfish. This implied figuring how to design the three main parts of the robot: the base, the head and the tentacles.

The first solution found was a paper prototype that envisioned general dimensions and one other which tried to explore different solutions for what concerns the fabrics.


First mockup of a jellyfish.

## Concept

By creating an organ-like element that attaches to the human body and rests on the shoulder, an element that could detect motion and sound and react accordingly by means of a built in responsive nervous system of motors, a PCB, and wires, we aim to aid children with social and emotional difficulties not only go through life but enjoy life and express themselves easier and better. As designers and engineers, we have the tools and knowledge necessary to make human life not only easier but much more entertaining for living beings that are not well heard.

Jell-e represents a transitional object and a revolution for the emotion field: it will cover every gap kids could find along their path in showing their feelings, fighting their difficulties in approaching and interacting with other people.

# Phase 3: Develop

In this phase we describe the development process, departing from the first prototype to the final improvements regarding:

## Strategy

Since the project started we divided the tasks in three main categories and developed them independently: the general design of the robot structure, the design of the mechanical tentacle and the selection and testing of the electronic components.

The robot structure required the selection of different materials in order to make the robot comfortable for the wearer, and also to not affect the sensor functionalities, especially for the touch sensor, that it is enveloped by the fabric, and testing we discovered that some materials affect the sensor sensibility more than the other. After many trials we selected the material that provides the minimum sensibility reduction to our sensor.

The design of the mechanical tentacle, our main actuator, required many different trials in order to find an easy structure that can be expressive, flexible and light weighted at the same time. The main idea that was present since the first prototype was to control the movements using two servo-motors and fishing in order to bend the tentacle along the x and y axis.
We started with a prototype, using a flexible rubber pipe as structural bone but it was very difficult to control the movement so we discarded this kind of structure and opted to 3D printing. After some trials, we managed to find a very reliable and flexible structure that is well controllable and suitable for our robot.

Regarding the electronic components, we tested the servo-motors once the tentacle was ready, and the sensors were tested one at a time, already implementing the function needed for our final work.

## Electronics

During our various tests and trials we connected our components using a breadboard and jumpers, allowing us to be faster during the prototyping and easier to change everything in case of problems on the circuit.
Even if this solution was good for the first phases, it was not suitable for our final project because it doesn't guarantee stability and cables can detach easily for the breadboard or the microcontroller. Therefore we soldered all our components onto stripboard and used connectors to guarantee stability and toughness to the circuit. Furthemore, the stripboard allowed us to reduce the space occupied from the electronics, which is essential for a wearable robot like ours.

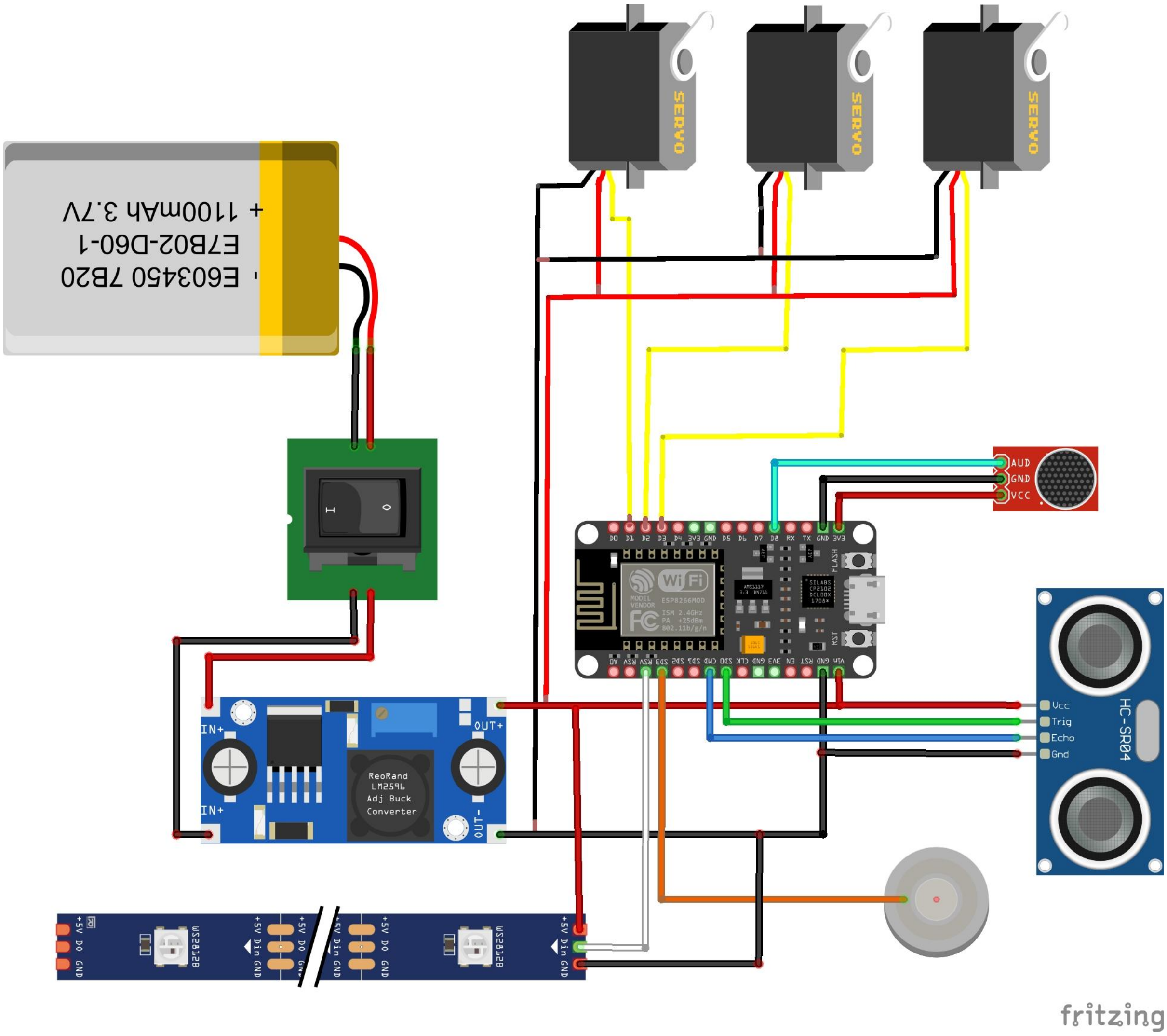



Diagram of the circuit developed, host inside the head. (Illustration obtained with fritzing.org)

# Bill of Material (BOM)

The following table summarizes the list of material used for the development phase.

The list of material has been subject of several changes, according to the modification of the emotions and interactions the team tried to achieve, to reach the best expressivity for Jell-E.

| Material | Quantity |
|---|---|
| ***Servomotor***<br>Robotic tentacle - Interactions | ***3*** |
| ***ESP micro controller***<br>Main functionality | ***1*** |
| ***Battery 1700 mAh***<br>Main functionality | ***1*** |
| ***Addressable RGB LED strip***<br>Eyes - Emotions | ***TBD*** |
| ***Capacitive Touch Sensor***<br>Tentacle - Interactions | ***TBD*** |
| ***Voltage step-down converter***<br>Main functionality | ***1*** |
| ***Ultrasonic distance sensor***<br>Eyes - Interactions | ***1*** |
| ***Microphone***<br>Tentacle - Interactions | ***1*** |
| ***Amplifier***<br>Tentacle Interactions | ***1*** |

Initial BOM. Available as PDF here.

# Coding

All the code written is uploaded in a github repository.
The repository structure is divided into two main folders:

- the “arduino” folder where there is a sketch for each device. These sketches are used as already said to test independently the components and separately implementing the functions of our robot.

```
arduino
├── addressable_led
│   └── addresasble_led.ino
├── microphone
│   └── microphone.ino
├── servo_arduino
│   └── controlledservo.ino
├── servo_easy
│   └── servo_easy.ino
├── tentacle_control
│   ├── tentacle_control.ino
│   └── undefined
│       └── Arduino Pro IDE
│           └── 2022-04-22_log.log
├── tentacle_control_v2
│   ├── tentacle_control_v2.ino
│   └── undefined
│       └── Arduino Pro IDE
│           └── 2022-04-22_log.log
├── touch_sensor
│   ├── circuit.png
│   └── touch_sensor.ino
└── ultrasonic_sensor
    └── ultrasonic_sensor.ino
```

Structure of the arduino folder where all sketches are placed.

- the “robot” folder, where our main code is placed. This folder is well organised and developed in this way:
  The “main.ino” file, where each device is set up and each sensor is interrogated in a polling way inside the void loop function. Sensors and actuators are developed through classes,and each method implemented corresponds to the gesture implemented from our robot and the reading part of the sensor.
  The Include folder, mainly contains the class definitions of sensors and actuators, the pin.h file where board pins are defined, and the extras header which contains some common functions among the different classes.
  The src folder instead contains the classes implementations.

```
robot
├── Include
│   ├── Actuators
│   │   ├── LEDStrip.h
│   │   └── Tentacle.h
│   ├── Devices.h
│   ├── Extras.h
│   ├── pin.h
│   ├── Sensors
│   │   ├── Microphone.h
│   │   ├── TouchSensor.h
│   │   └── UltrasonicSensor.h
│   └── TestFunctions.h
├── main.ino
└── src
    ├── LEDStrip.cpp
    ├── Microphone.cpp
    ├── Tentacle.cpp
    ├── TouchSensor.cpp
    └── UltrasonicSensor.cpp
```

Structure of the robot folder where all the code of the robot is organised.

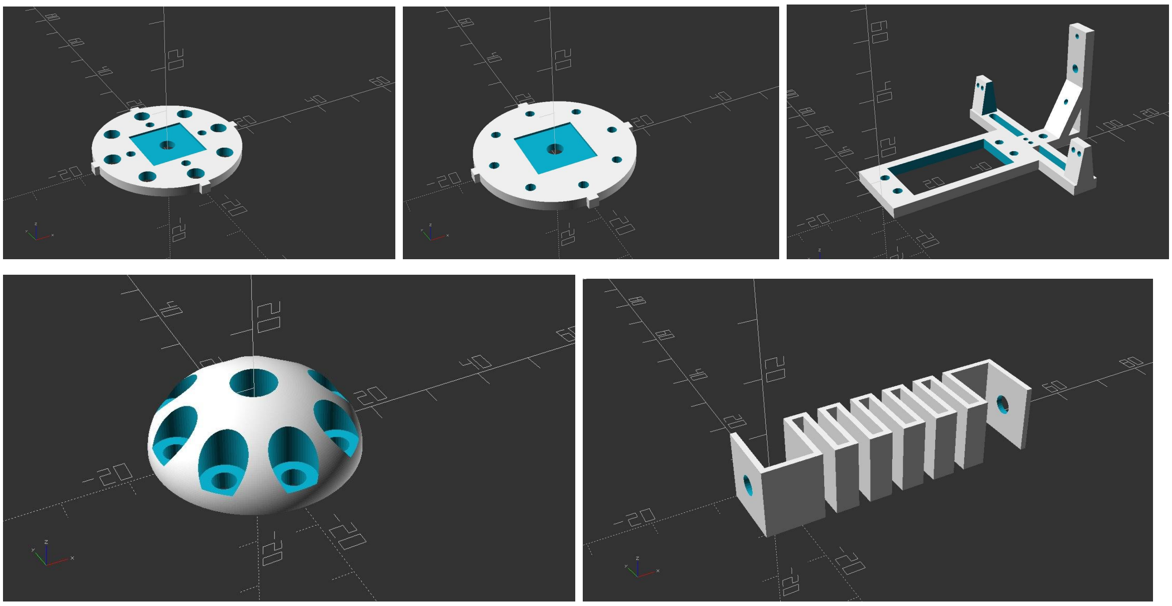
.

During the testing of components, since they were used independently we used the delay() function of the Arduino library in functions where waiting is needed. The problem of this function is that it blocks the microcontroller until the time is elapsed, and so during the waiting period the microcontroller cannot perceive anything. As a solution we changed the code structure, using the millis function; this instruction gets from the microcontroller the current timestamp, and continuously checks whether to perform an action or not, looking at the difference between the current timestamp and the first timestamp save. This solution is a little bit trickier to implement but it is a non-blocking way to set time intervals.

# Structure

## Robotic tentacle

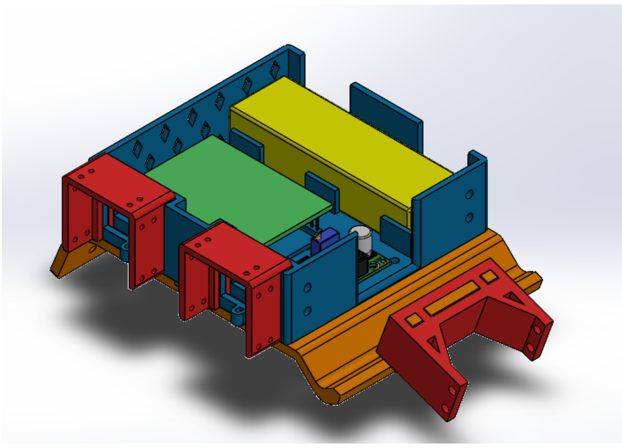
During the development phase our purposes were to find the best structure of the tentacle and to create the housing for the motors.
The first 3d printed tentacle was composed of some rigid pieces connected by cylinder joints but it was too rigid and not very natural on the movements, thus we decided to use spring shape pieces as the main structure and disks as joints. Then we did some trials to find the optimal value for the thickness of the springs. When bending along one axis, the controllability along the other axis decreased: to avoid this problem, we inserted some thin pipes around the tendons to keep their length fixed in every section. The fishing lines were too loose when we fixed them with screws at the last disk of the tentacle, thus we chose to add a rail for each tendon to fine-tune its length. The stress on some parts of the tentacle was so high that there was a risk of breaking it, so we needed to redesign the holder of the servos to reduce the angle made by the fishing line.

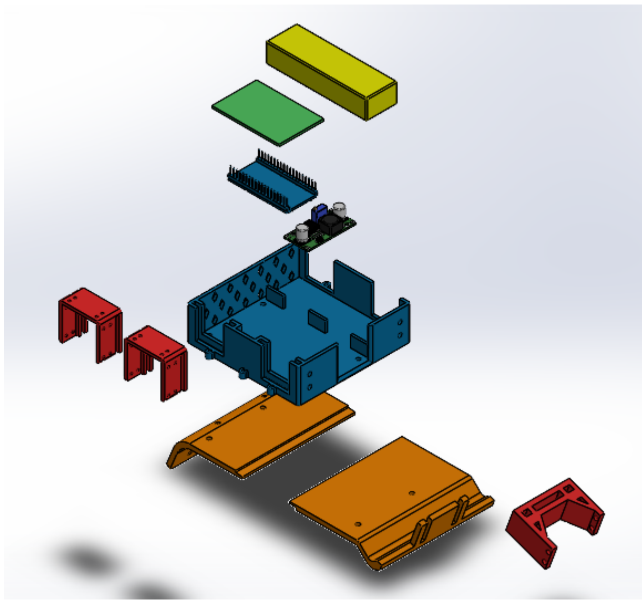


Parts of the mechanical arm 3D modelled on OpenSCAD

## Box of components

The further development of the design brought to a better definition of the box that hosts the hardware, to fit with the new requirements due to the variations of the components in terms of typologies and numbers.

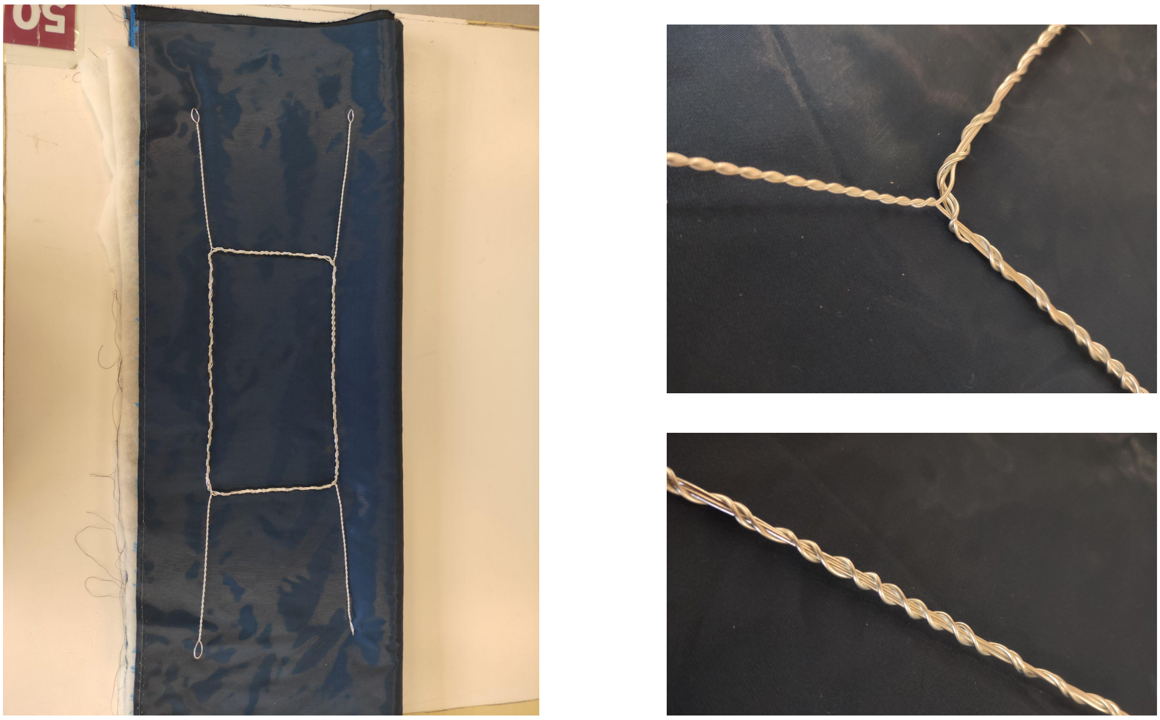




Assembly and exploded view from Solidworks.

# Shape

The base has the goal to be as much adjustable as possible, in order to fit with any kind of shoulder dimensions and could make the jellyfish able to be worn by kids and adults. This goal is planned to be achieved by implementing a metallic wire inside the fabric in order to make it moldable and adjustable.



Based obtained by implementing a metallic wire inside the fabric

Development process of the head, implemented with LED strip light and ultra sonic sensor.

The head will have a design which has a central common part and 4 cuts along the connections in order to make it round and 3 dimensional.

Tentacles will be differing one form the other according to the scope: mechanical arm, microphone, capacitive sensor.

## Name of the robot

The identity of Jell-E is improved by selecting the name “Jell-E” which embodies the name of the animal which the team has taken inspiration from, and a robotic influence, as for the famous Pixar robot Wall-E.

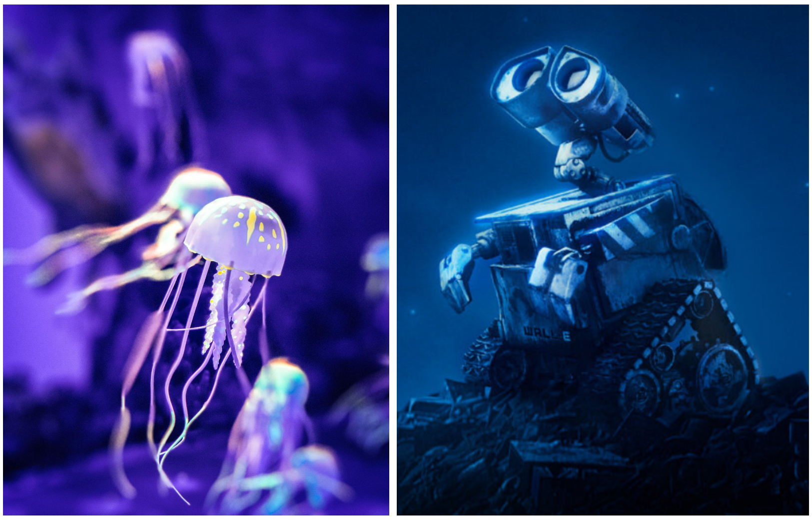


Photo of jellyfish by Jere Bussola on Unsplash and Wall-E from Pixar Studio.

# Phase 4: Deliver

In this phase we describe the final robot. You can repeat some paragraphs from the development process if needed.

## Final Robot description

### Logo

The brand identity has been increased by designing a logo which aims to explain the main features of our robot, which has different tentacles but only one is the real protagonist. The name is also splitted into two main parts, one comes from the animal we took inspiration from, the other to give a more robotic feeling.

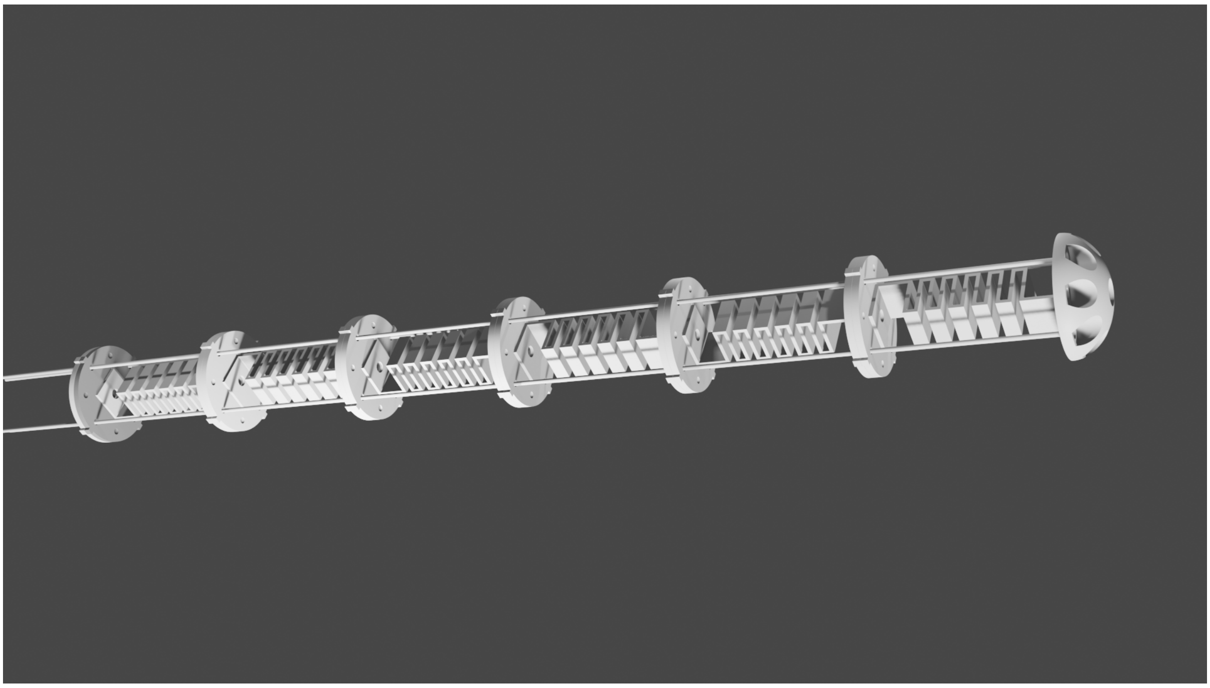
Logo Jell-E. Animation of the logo available here.

## Structure and mechanics

### Robotic tentacle

The final robotic tentacle has been designed in order to respond to a simple but optimal mechanism to move along two axis driven by two servomotors. The initial idea was to have as less components as possible: we designed just two parts, the joint ring (used as double) and the flexible spring (used in an alternated way, to permit the movement both up and down and to the left and to the right),, that constitute the whole body of the tentacle, which is closed by a simple tip. The entire part is made movable thanks to nylon strings attached to ebery single joint. All the parts are 3D printed and sliced by the teammates, realised in their final version after several tests.

The final shape is presented in the following render.

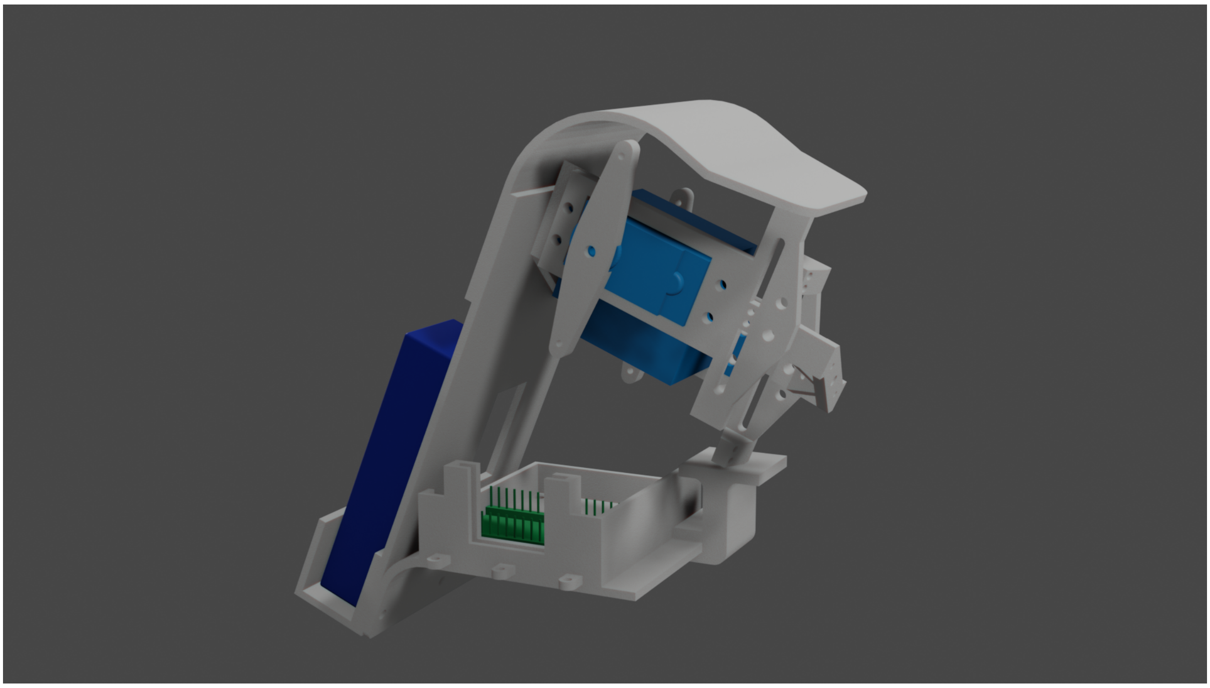


Final render obtained using Blender (Evee). The animation file is available [here](here).

## Internal components

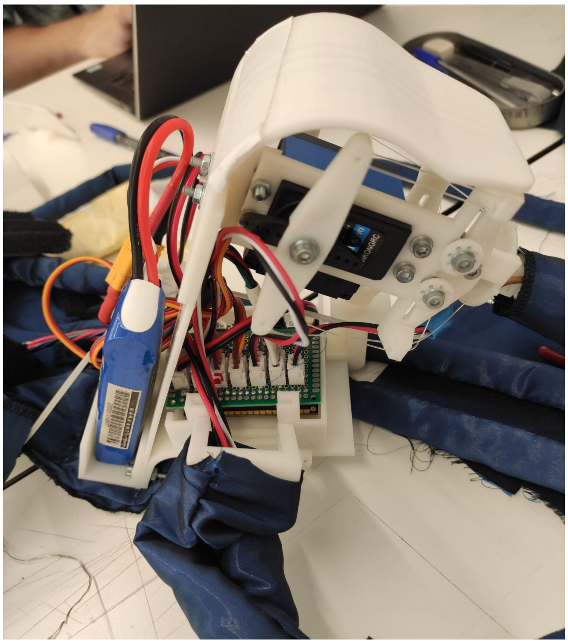
The internal components and its container has been subject of several changes: the main goal was to fit both the pure electrical part together with the servomotors for the tentacle, which occupied the biggest amount of space and has always represented **the most critical part for our design**. The new disposition of the components and the outer shell permits to fit the motors inside the head, having ESP board, step down and batteries both below or behind the motors themselves.

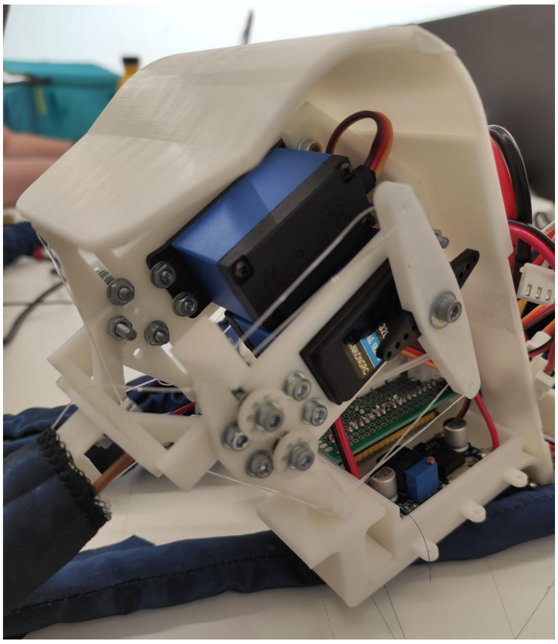
The final shape is presented in the following render.



Final render obtained using Blender (Evee). The animation file is available here.

The outer shell, which is in contact with the fabric, has been optimised until the very end, in order to let all the needed wires fit inside the head as well. The final version of the 3D model, available in Solidworks as a open source on the shared folder of Google Drive has three more changes from the animation, also visible in the previous render: the first regards the plate on the back, which has been increased in length of 2,5 cm, to let the wires fit in a more suitable way; the second is a support part, which has the role of keeping the weight of the servos and avoid bending of the plate previously mentioned, while the last is an optimization of the upper cover, which has more rounded corner in order to better fit inside the fabric.





Internal components of the head.

## Shape

The final shape has been optimised to obtain a head which fits perfectly with the final design of the internal components. Also the adapter for the shoulder has seen a radical change, to give more stability to the entire product.

### Head shape

The final head shape is designed to contain the inner structure while maintaining jellyfish-like appearance. By building the inner structure higher to contain layers of electronics, we manage to minimize the overall dimension of the head to be better suitable for the kids. The outside of the head is made by two layers of fabric sandwiched one layer of flutty to provide the soft touch.
Ultrasonic sensor is put in the front of the head as eyes. To highlight the eye region which will always be the part attracting most attention, we re-designed the part with rounded shape and led light strip.

Final shape of the head. The tentacles are the structural parts and come covered with paper and tape to avoid issues with the fabric.

### Eyes and emotions

The decision of how to visualise the color LEDs to show the emotion has been a critical part of the design process. The final verdict opted for a simple but interesting solution, which considered two layers of white material, sewn together to create a long circular pocket where to insert the addressable LED strip. On the top of it, a plastic quadri-circular shape has been obtained to fix the eyes from the outside, helped by two rubber gaskets (standard parts for ultrasonic sensors). Since the sensor is inserted from the inside it helps to clamp all the materials together, creating a strong solution for the final product.

Development process of the eyes shape.

Final eyes evolution, before being covered with the outer transparent layer of fabric.

## Fabric

From the earlier stages, we decided to use blue fabric, to refer to the sea world. After several testing of various blue fabrics, the selection oriented towards a soft and a little bit shiny material. We wanted to have a more original solution with respect to the classical fabric used in “peluche” world, to also have the chance to give Jell-E a more elegant appeal.

Compare and test blue fabric with different degrees of transparency and softness.

The padding for the infill.

## Shoulder Adapter

Despite the previous design of the shoulder adapter had a concept idea that was interesting and original, since it aimed to reach a compromise between stability and relation with the product in terms of fabric, the final design has been oriented to a more stable and professional solution, which involved the use of a shoulder brace.

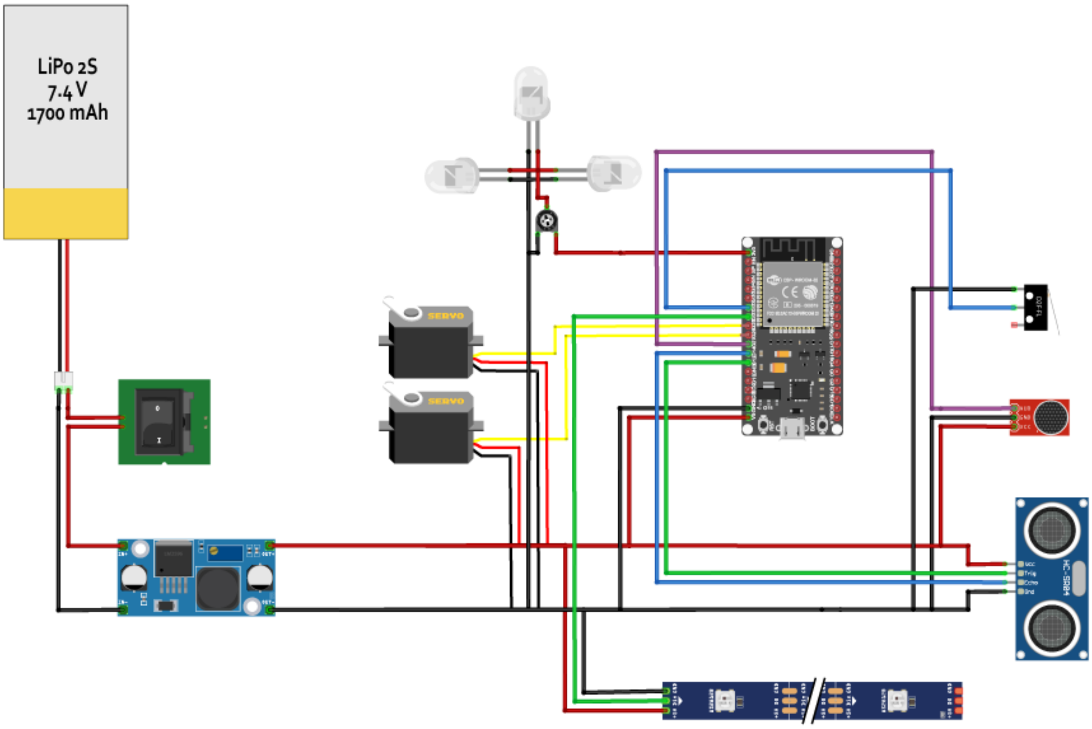
The idea is to have a standard part that can simply be customised and fits perfectly according to the dimension and size selected. The material is stretchable and the product comes with a long velcro tape that gives enormous stability to the product. The customization we carried out regards the padding in the internal part and two cuts to let the head fits, fixing the velcro which is used both in the head structural parts and in the outer side of the padding itself, which is covered by the same fabric of the head, in order to give continuity to the product.

The size of the standard product purchased is the largest one (size 3) to let the testing phase during the exam date easier and friendly for everyone.

Final shoulder adapter: standard piece purchased from Decathlon, customized in Fashion Lab, Bovisa.

# Electronics

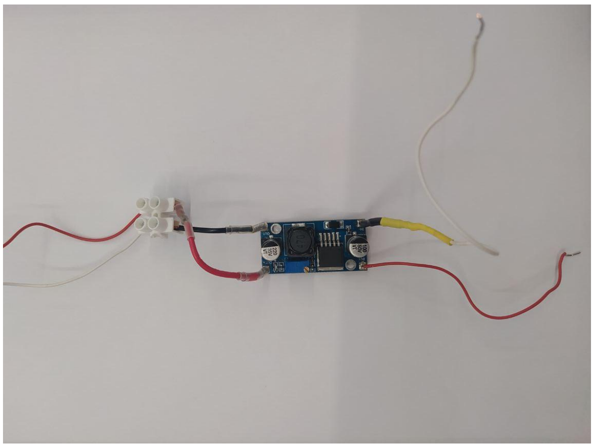
At the end the circuit underwent some changes. The tip servo motor was removed since that feature is not implemented anymore, the microphone is now supplied at 5V and we added a potentiometer and a series of leds connected to the 3.3V.
The microphone previously was supplied at 3.3V but during the function testing we observed that it works better at 5V.
For what concerns leds, we added them to give a better appeal to Jell-e. They are simply connected to the power supply, and stay on when the robot is on. We also placed a 100Ω potentiometer in order to regulate leds' brightness.
We easily adapted our stripboard to these changes: the microphone is connected in place of the tip servo motor and the leds are in turn connected in place of the previous microphone connector.

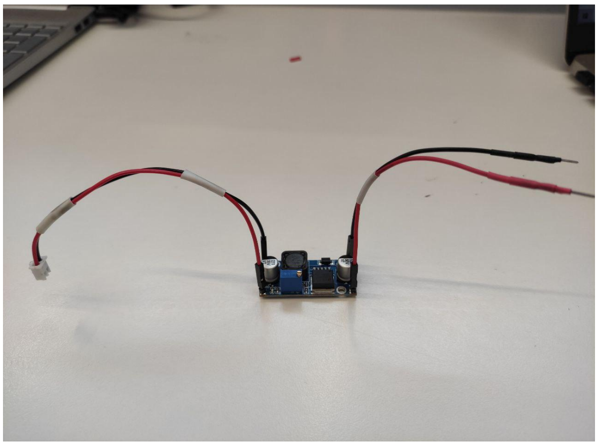



Final diagram of the circuit developed. (Illustration obtained with [fritzing.org](fritzing.org))

## Step down: a complex love story

Some technical issues regarding the step-down connections have been highlighted during the design process: we soldered the wires directly to the input and output plates, figuring connections were really fragile, and easy to break. In order to prevent any braking and to improve the robustness, the solution was oriented towards having four male connectors able to let the wires being plugged into the step-down itself.





Old version and current version of the step down.

## Bill of Material (BOM)

The following table summarizes the final list of material used for the delivering phase.

| ***Material Robot*** | ***Quantity*** |
|---|---|
| ***Servomotor***<br>Robotic tentacle - Interactions | ***2*** |
| ***ESP micro controller***<br>Main functionality | ***1*** |
| ***Battery 1700 mAh***<br>Main functionality | ***1*** |
| ***Addressable RGB LED strip***<br>Eyes - Emotions | ***10*** |
| ***Limit Swtich***<br>Tentacle - Interactions | ***1*** |
| ***Voltage step-down converter***<br>Main functionality | ***1*** |
| ***Ultrasonic distance sensor***<br>Eyes - Interactions | ***1*** |
| ***Microphone***<br>Tentacle - Interactions | ***1*** |
| ***LED strip light***<br>Cover - Emotions | ***20*** |
| ***Shoulder adapter***<br>Stability | ***1*** |
| ***Velcro***<br>Stability | ***20*** |

Final BOM. Available as PDF here. Final excel file with links of providers available here.

## Coding

```
esp32
├── esp32.ino
├── Include
│   ├── Actuators
│   │   ├── LEDStrip.h
│   │   └── Tentacle.h
│   ├── Devices.h
│   ├── Pins.h
│   └── Sensors
│       ├── Button.h
│       ├── Microphone.h
│       └── UltrasonicSensor.h
└── src
    ├── Button.cpp
    ├── LEDStrip.cpp
    ├── Microphone.cpp
    ├── Tentacle.cpp
    └── UltrasonicSensor.cpp
```

Structure of the esp32 folder where all the code of the robot is organised.

With respect to the development phase we did some modifications on the old “robot” folder without changing the overall structure: we changed the name of the folder into “esp32”, the “main.ino” file was renamed “esp32.ino”, and “Extras.h” and “TestFunctions.h” were deleted because they were not anymore useful. The “esp32.ino” file manages the main flow of the program: scans all the sensors (ultrasonic sensor, microphone, limit switch) and, if it is detected any measurement that is going to verify a specific condition, does a certain action moving the tentacle connected to the servo motors and expresses an emotion lighting up the addressable LED strip with a color. When Jell-E is not detecting anything, its LEDs simulate a breath changing from low to high intensity and vice versa.

Each sensor and actuator has two files: .h file where we defined the new class with its variables and functions and .cpp file where we implemented their functions regarding their operations. Specifically, we have these files:

- “LEDStrip.h” and “LEDStrip.cpp”: implement the functions of the addressable LED strip. Each function expresses a particular emotion changing its color. For example, when it is sad, LEDs turn on blue or when it is angry, LEDs turn on red.
- “Tentacle.h” and “Tentacle.cpp”: implement the functions of the tentacle moving the two connected servo motors. Each function does a certain movement depending on the mood of the jellyfish. For example if Jell-E is happy, the tentacle does a V shape movement or if it is sad, the tentacle goes down close to the wearer.
- “Button.h” and “Button.cpp”: implement the functions used by the limit switch. A function reads the signal of the limit switch, one updates the pressure counter, another resets the pressure counter.
- “Microphone.h” and “Microphone.cpp”: implement the functions used by the microphone. A function reads the values from the microphone and one computes the average of 50 read values because we want to delete the noise of the environment and of the microphone.
- “UltrasonicSensor.h” and “UltrasonicSensor.cpp”: implement the functions used by the ultrasonic sensor. A function reads the values from the ultrasonic sensor, one

updates a counter if the sensor detects a new value that is bigger than 20 with respect to the old one (this is done to implement the greeting from Jell-E).

Every action of Jell-E lasts around 6 seconds.

We used the following libraries:

- “ServoEasing”: used to have a more sophisticated control of our servos and a more fluid motion of the tentacle.
- “FastLED”: fast and efficient for programming our addressable LED strip.

Connecting all the sensors and actuators we found out some problems: we had to change implementation of few lights because some were blocking the flow of the program and so, during the waiting period, the microcontroller cannot move the tentacle; the behavior of others was different from what we expected, thus we decided to change them with a better representation of the emotion. We had to test the microphone multiple times to understand the best threshold for when a person is screaming because the microphone had lots of noise.

Link to the official Jell-E code repository: https://github.com/leonardogargani/jell-e

# Conclusion

## Mid term conclusion

At the beginning of our experience on this project, each component of the group did its own research about the concept the professors gave us, to strengthen the concept idea and to finalize a design decision. The difficulties at this stage has been of several typologies: coming up with a single idea that everyone agreed for has not been a trivial task, taking into consideration time management and our acknowledgement. Therefore, the team learnt how to deal with simple and more complex decision making situations, in order to reach a compromise where every idea could find its own space in, at least, some features and peculiarity. Splitting the workflow and tasks among each component, according to the soft and hard skills of everyone, has been a complex task too: the management of the different capabilities followed a dynamic scheme, in which everyone tried to give their own support, according to the problem solving abilities, software and hardware skills and communication expertise.

Building a wearable robot, as stated during the brief presentation, has not been a trivial task. The wearable constraint, which was followed by the ability of interacting with other people made the project quite complex, a scenario where not all the components were comfortable in. We learnt to work on a multidisciplinary team, where each member had different background and skills: none of us knew any components of the group, which means the first task was understanding and analysing each person's strengths and weaknesses, in order to be able to better organize the workflow. Furthermore, we learnt how to schedule meetings so that everyone could attend them, taking into consideration all our different engagements, having different projects and tasks to work on. The team is made of students from different majors and departments and despite the differences in the working approach we managed to work together, staying focused on the final goal.

## Final conclusion

The timing has been really short and we had to learn how to make decisions quickly, taking into consideration any changes on the go, to smooth the work and be able to present the most optimal solution.
We are satisfied with the result, since, after having spent the last days testing it, the robot interactions work fine. This lets us record different videos to explain every different ability of Jell-E: unfortunately, we have not been able to implement the tip, as planned, since the beginning. That could have given more expressivity and character to the robot: for this reason we would like to add it as a part of further development for anyone who would like to take care and to keep working on it. Moreover, the head appearance could be another point of further development: we understand the appearance is quite fundamental, even more so in a kid toy. The goal would be making the appeal more friendly: a suggestion may be trying to use a different fabric, easier to sew, and strong enough to avoid fraying.

# APPENDIX

# Minutes of the Meetings

## Lesson 29/03/2020

Time: 9:00-18:00
Venue: Bovisa Campus - Prototype Lab - Politecnico di Milano
Attendees: All members

- First lecture, presentation of the brief, team creation
- Brainstorming about wearable robots and possible field of application: research through images, related articles or papers on Google Scholar
- Creation of a shared board on Miro, which is the main program used to collect and share information and insights among the group
- Research subdivided into three main categories: Scenarios, Technologies and Materials
- Focus on the ludic part according to professors' feedback: research focused on existing robots able to communicate emotions
- First presentation of the overall idea: a jellyfish-based robot dressed in the upper part of the body which can interact through showing colors, emitting sounds or making movements with the aim to help the child (dresser) to express emotions.

## Meeting 01/04/2022

Time: 10:00-13:00; 14:00-16:30.
Venue: Leonardo Campus - Politecnico di Milano; Brico (afternoon)
Attendees: All members

- Brainstorming session about the possible design of the whole robot, how to make it attached to the wearer?
  - a belt on the waist
  - put on the shoulder, stabilized through buttons or velcro tapes
- Analysis of Youtube existing projects of wearable robots fabrication (from DIY to professional fabrications)
- Analysis of an inspirational video tutorial to create an octopus-shaped robot (https://www.youtube.com/watch?v=8OTIL84Wirs)
- Discussion of the possible structure and material of the tentacles. Brainstorming session about the aim of the tentacle.
  Interactions
  - give me five
  - stay way,
  - morra cinese (rock-paper-scissors)
  Emotions
  - curious
  -scared
  -happy

- Discussion about the possible hardwares needed and first draft of the components list.
  - 4 servo motors
  - microphone
  - DC motor
  - arduino
  - LED
  - pipe pvc
  - wires
  - fishing wire
  - raspberry pie
  - buttons
- Afternoon spent at Brico to investigate the possible materials for the structure of the tentacles and the robot in its overall.
  Purchase of two different type of metallic wire to create the rigidity needed, plastic flexible tube to make the skeleton of the tentacle
- Update of the report

## Meeting 08/04/2022

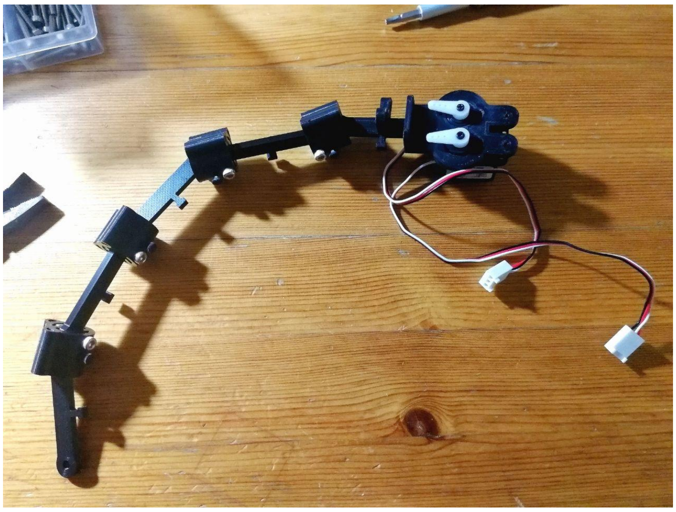
Time: 10:00-13:00
Venue: Leonardo Campus - Airlab - Politecnico di Milano
Attendees: All members

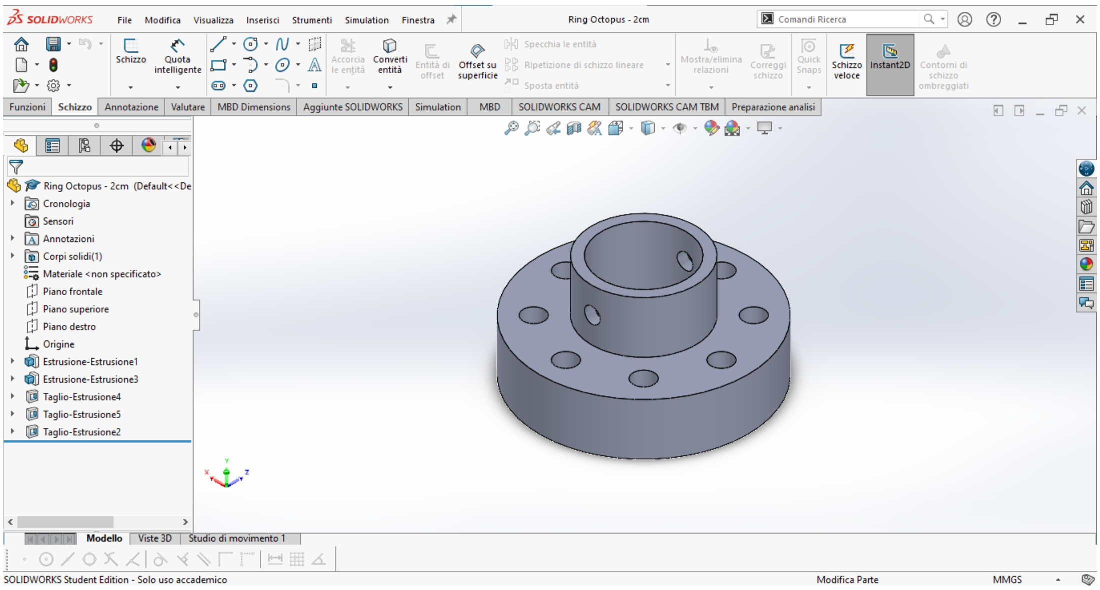
- Exploration of materials and hardware present in AIRLAB.
- Update of the material list.
  - Fishing line
  - Wires
  - Buttery holders
  - Raspberry pi/Arduino nano/esp32/Arduino micro
  - 3 Servo motors
  - Speaker
  - Led RGB
  - Optical fiber
  - Microphone
  - Pressure sensors
  - 3D printed parts
  - Batteries
- Research on fabrics and E-textiles
- Consultation of a book on materials, fabrics and different application and solutions: "Textile visionaries: innovation and sustainability in textile design" - Quinn, Bradley, 2013 - available in Bovisa Library or at the following link: https://www.amazon.com/Textile-Visionaries-Innovation-Sustainability-Design/dp/1780670532)
- Further research about the possible way of tentacles and the whole shape.
- Update of the report

# Meeting 12/04/2022

Time: 16:00-18:00
Venue: Leonardo Campus - Politecnico di Milano
Attendees: All members

- Start of the modelling process with parametric Computer-Aided Design programs (Solidworks 2020; OpenSCAD)
- First attempts of 3d printing some of the parts to create the skeleton of the tentacle



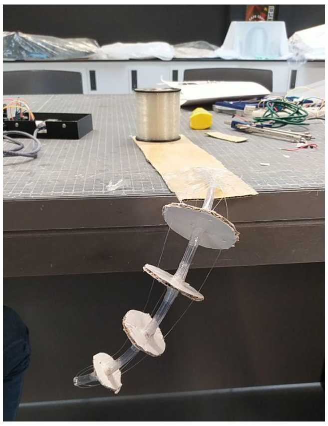
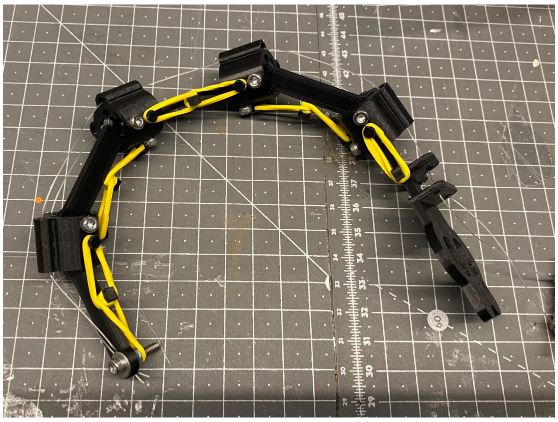



- Update of the material list.
- Organization of the different tasks for the first presentation: having three people working on the single working tentacle with different materials and solutions, two people making the whole jellyfish body, including the head, to test different manufacturing processes and shapes.
- Update of the report

# Meeting 22/04/2022

Time: 10:00-16:00
Venue: Leonardo Campus - Politecnico di Milano
Attendees: Giorgio Brugali and Leonardo Gargani

- Prototypes of two different working tentacles with different mechanisms and materials solutions: one with flexible tube and fishing wires, the other with 3D printed parts, screws, nuts and rubber bands.
- Update of the report

# Lesson 26/04/2022

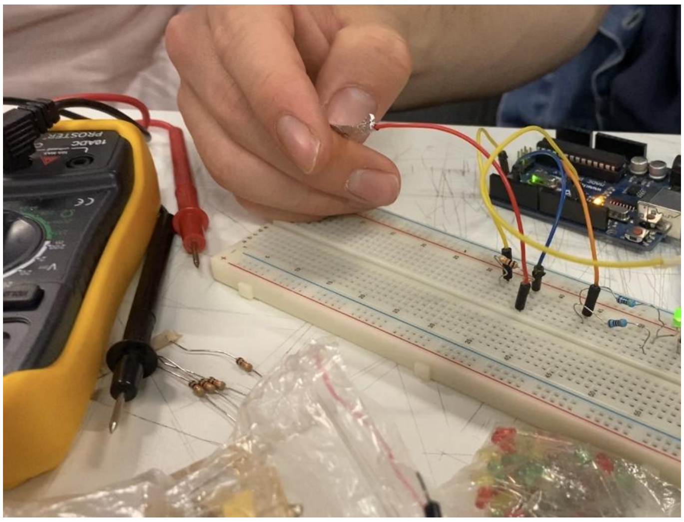
Time: 9:00-18:00
Venue: Bovisa Campus - Prototype Lab - Politecnico di Milano
Attendees: All members

- Presentation of the 5 different prototypes realized during the first months of work
- Analysis of the flexible tube with cavities and cuts to made with cutters to better test its flexibility and capability of rotate and bend
- Discussion of the new design of the rings to use for the skeleton of the tentacle
- Discussion about emotions and interactions needed to tackle the functionality of the robot, which has to be also a ludic item

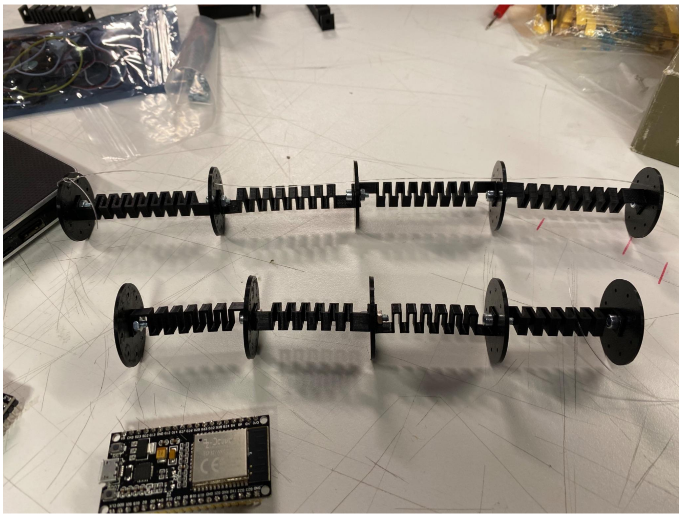
# Meeting 30/04/2022

Time: 14:00-18:00
Venue: Leonardo Campus - Politecnico di Milano
Attendees: All members

- Material analysis (fabrics and e-textiles)
- First test of the capacity sensor



- Discussion about a new design of the tentacles proposed, aiming at a more flexible and lighter solution



- Discussion about how the jellyfish expresses its feeling through colour and movement
- Definition of the further steps to be on time with the GANTT
- Update of the report

## Lesson 03/05/2022

Time: 9:00-18:00
Venue:  Bovisa Campus - Prototype Lab - Politecnico di Milano
Attendees: All members

- Discussion of the use of the new flexible solution: possibility to have a super flexible tip that could become the main part of the character of the robot; possibility to alternate different orientation of the flexible part to obtain a multi axial movement (as suggested by the professors)
- Change of the design of rings, tip and skeleton and test with the 3D printer present in the Lab

- First design of the flowchart to better understand the steps needed for a smooth interaction process

## Meeting 04/05/2022

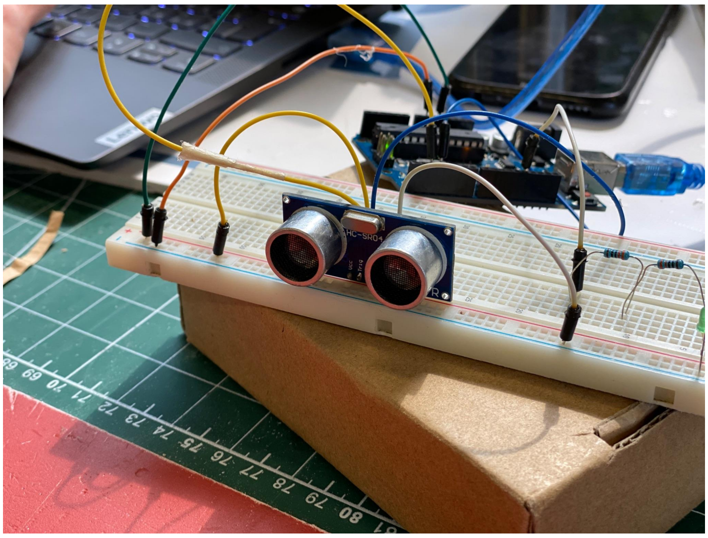
Time: 14:00-20:00
Venue:  Leonardo Campus - Airlab - Politecnico di Milano
Attendees: All members

- Discussion about the flow chart
- Further development of the mechanical tentacle
- Test of the LED lights
- Discussion of the possible structure of the head: how to join fabric and metallic wire
- Update of the report

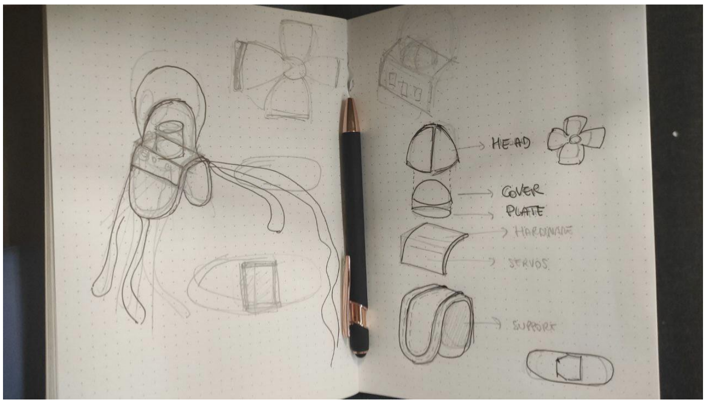
## Meeting 09/05/2022

Time: 15:00-19:00
Venue: Bovisa Campus - Prototype Lab - Politecnico di Milano
Attendees: All members

- Finalization of the flow chart.
- Test of the ultrasonic sensor with a positive result, which gives feedback according to the movement of a third person when doing “hello” with the hands



- Definition of the mounting structure for the shoulder
- Sketch of the components needed and an exploded view to better understand the composition




- First tests of possible fabrics for the tentacles
- Update of the report

## Lesson 10/05/2022

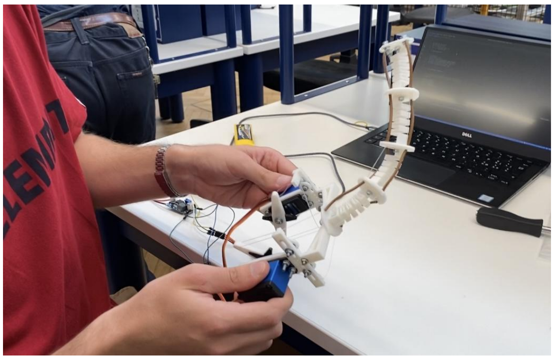
Time: 9:00-18:00
Venue: Bovisa Campus - Prototype Lab - Politecnico di Milano
Attendees: All members

- Optimization of the flowchart, according to the feedback of the professors
- Optimization of the robotic arm
- Definition of just one single articulated arm, in order to give to it the maximum focus and give less importance to the others tentacle, which will be just supports for stability and host of some components

## Meeting 12/05/2022

Time: 10:00-19:00
Venue: Leonardo Campus - Airlab - Politecnico di Milano
Attendees: All members

- Two motors mounted on the mechanical tentacle and it functioned well.



- Test of the microphone, calibrate the microphone, the distance of sensor detection
- Prototype of the tentacle to put in a capacity sensor.
- Prototype of the base with metallic wire which give stability and let different users' size to wear it

- Discuss the shoulder adapter and how to place the hardware in the head.
- Update of the report

## Lesson 17/05/2022

Time: 9:00-18:00
Venue: Bovisa Campus - Prototype Lab - Politecnico di Milano
Attendees: all members

- Definition of the role of the extra tentacles
- Definition for each part of the jellyfish of a specific role: head is the LED and components host, long tentacle hosts the capacitive sensor, short tentacle hosts the microphone, robotic tentacle plays the main movement.

## Meeting 19/05/2022

Time: 10:00-19:00
Venue: Leonardo Campus - Airlab - Politecnico di Milano
Attendees: All members

- Organization of the last two weeks of work before the delivery
- Optimization of the robotic arm and the inner components
- Test of the parts, movements and lights
- Update of the report

## Meeting 24/05/2022

Time: 10:00-21:00
Venue: Leonardo Campus - Airlab - Politecnico di Milano
Attendees: All members

- Finalization of the mechanical part and test of the entire robot within all its components and fabric parts for what regards the base for the shoulder
- Test of the base stability among the other classmates of the different group
- Tests of the components which give some issues for what concerns battery and step-downs
- Update of the report

## Meeting 26/05/2022

Time: 10:00-13:00
Venue: Bovisa Campus - Moda Lab - Politecnico di Milano
Attendees: Alessandro Caruso and Yeran Liu

- Definition of the models, dimensions and fabrics for the structure
- Use of the machine to make the base adapter for the shoulder with metallic wire constrained inside the fabric itself and create the possibility for the base to be adaptive according to the different shoulder is posed on
- Update of the report

## Meeting 27/05/2022

Time: 9:00-19:00
Venue: Leonardo Campus - Airlab - Politecnico di Milano
Attendees: Alessandro Caruso, Greta Corti and Giorgio Brugali

- Finalisation of the hardware component, 3D printed parts and test of the overall robot
- List of all the technical issues to be solved during the optimization phase
- Update of the report

## Meeting 29/05/2022

Time: 14:00-19:00
Venue: Leonardo Campus - Politecnico di Milano
Attendees: Giorgio Brugali, Alessandro Caruso, Yeran Liu

- Report finalization
- Collection of all the parts of the robot to assemble it
- Test of the components
- Update of the report

## Delivery 31/05/2022

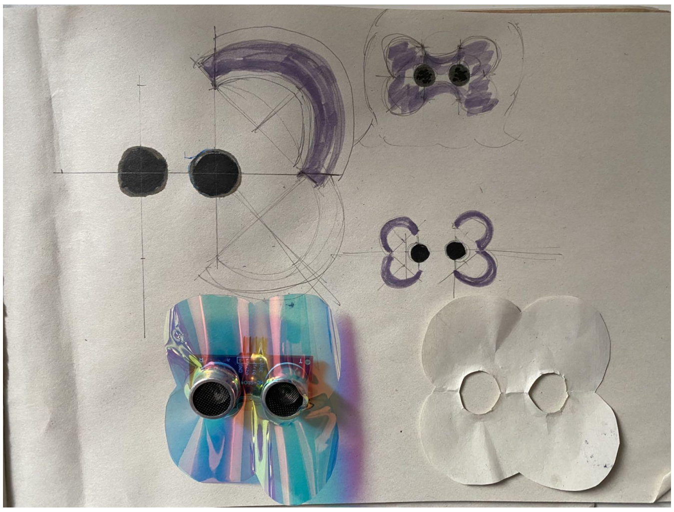
Time: 9:00-14:00
Venue: Bovisa Campus - Spazio Idea - Politecnico di Milano
Attendees: All members

- Presentation of the state of the art
- Feedback from professors about further changes and development

## Meeting 03/06/2022

Time: 14:00-19:00
Venue: Leonardo Campus - Politecnico di Milano
Attendees: Giorgio Brugali, Leonardo Gargani, Yeran Liu

- Discuss the possibility of using capacitive sensors, finding it hard to integrate to the whole robot. So test the other way to realize the function of “control tentacle”.
- Improve the appearance of the jellyfish head. Add Christmas lights into the outer layer, and design the parts around the jellyfish eye region.



## Meeting 07/06/2022

Time: 9:00-19:00
Venue: Leonardo Campus - Airlab - Politecnico di Milano
Attendees: All members

- Definment of the internal design (Solidworks model)
- Test of the solution of the eyes (with fabric and sensor)

## Meeting 10/06/2022

Time: 14:00-19:00
Venue: Leonardo Campus - Airlab - Politecnico di Milano
Attendees: all members

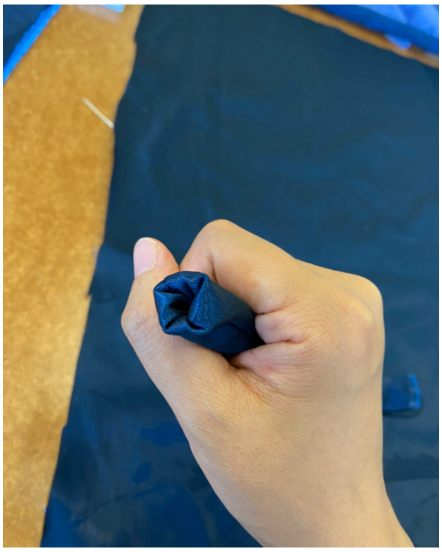
- Tests of the sensors connected simultaneously and the response.
- Model and print the internal structure of the head.
- Find a good material for making the eyes.

- To better resemble the jellyfish, new dimensions of the head and tentacles are designed. A new mock-up with paper is made to see the effect.

## Meeting 14/06/2022

Time: 9:15-18:15
Venue: Bovisa Campus - Fashion Lab - Politecnico di Milano
Attendees: Alessandro Caruso and Yeran Liu

- New structure to stabilize the robot is designed.
- New long tentacles with flutty fillings are made for the better appearance of jellyfish.



Time: 14:00-21:00
Venue: Leonardo Campus - Airlab - Politecnico di Milano
Attendees: Alessandro Caruso and Leonardo Gargani

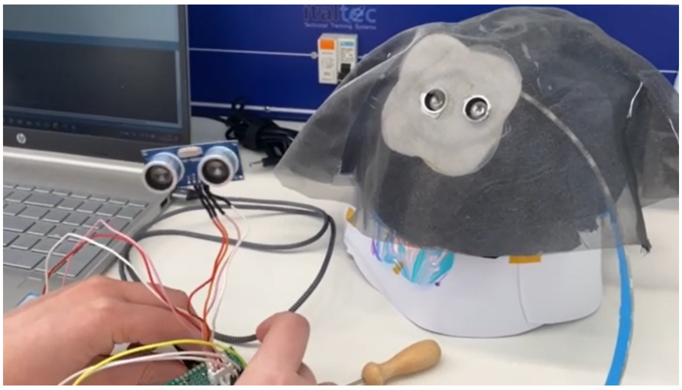
- Assembly and test of the spaces of the internal components
- New cables and connectors and correction of the previous

- Use of foam to create tentacles
- Define the final shapes and dimensions of the fabric and the padding
- Measurement of the long tentacles and identification of wires length for microphone and limit switch

## Meeting 15/06/2022

Time: 9:30-19:30
Venue: Leonardo Campus - Airlab; Bovisa Campus - Moda LAB - Politecnico di Milano
Attendees: Giorgio Brugali, Alessandro Caruso, Leonardo Gargani, Yeran Liu

- Tests of the motions of the tentacle and correct some problems with the sensors.
- Connect all the sensors, actuators, battery to the microcontroller and check if there was enough space for the wires, microcontroller, and step down on the 3d printed structure for the head.
- Solder some hardware components and substitute old cables with new resistant ones.
- Test if the design of presenting leds can work.

## Meeting 16/06/2022

Time: 9:30-12:30
Venue: Bovisa Campus - Fashion Lab - Politecnico di Milano
Attendees: Alessandro Caruso, Yeran Liu

- Finished the final jelly head with the right dimension for the base and all the tentacles with right dimensions.

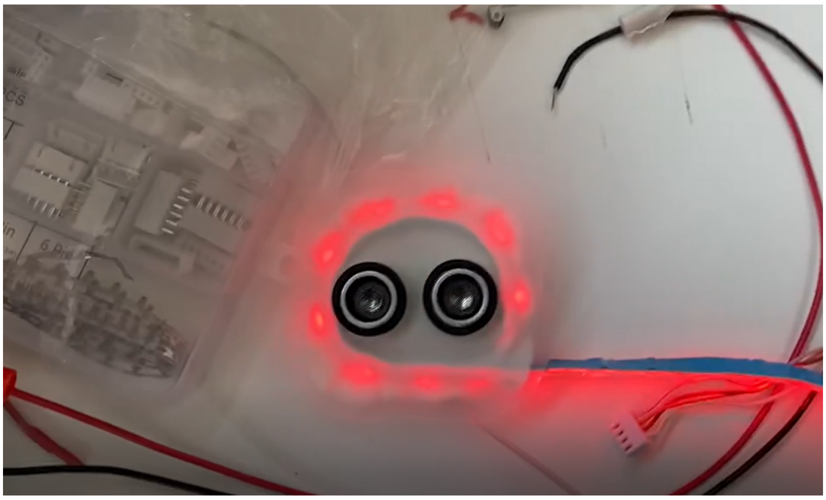
- Transparent fabric connected to the lights
- Eyes development and finalization: sewing the posket for the LEDs and finalised the final dimension

Time: 9:30-12:30
Venue: Leonardo Campus - Airlab - Politecnico di Milano
Attendees: Giorgio Brugali, Leonardo Gargani

- Fixed hardwares, cables and connectors soldered
- Testing the outer side of the fabric, explore how to connect the Christmas lights to the transparent fabric.

Time: 13:30-20:30
Venue:  Leonardo Campus - Airlab - Politecnico di Milano
Attendees:  Giorgio Brugali, Alessandro Caruso,  Leonardo Gargani

- Test the led lights into the eyes region with the final dimension.



## Meeting 17/06/2022

Time: 9:00-13:00
Venue: Bovisa Campus - Fashion Lab - Politecnico di Milano
Attendees: All members

- Test of the circuit (except for the microphone)
- Debug of the code for the interactions
- Animation on Blender for the technical assembly
- First approach to the video (slideshow of images and video taken during the entire course)
- External lights soldered (to be implemented on the outer shape)

Time: 13:00-21:00
Venue: Bovisa Campus - Fashion Lab - Politecnico di Milano
Attendees: Giorgio Brugali, Alessandro Caruso, Leonardo Gargani, Yeran Liu

- Finished the final jelly head with the right dimension for the base and all the tentacles with right dimensions.
- Planned for the video shooting of the final robot.
- Label of the product
- 3D printed logo


## Meeting 18/06/2022

Time: 9:00-19:30
Venue: Bovisa Campus - B2 Building & Bovisa Library - Politecnico di Milano
Attendees: All members

- Updating the report.
- Testing of the electrical components
- Cutting the head in correspondence of eyes and switch
- Some shots for the video taken
- Finished the final jelly head with the right dimension for the base and all the tentacles with right dimensions.
- Test the product with the fabric cover
- Shoot the video for the assembly process (time lapse)

## Meeting 19/06/2022

Time: 9:00-20:00
Venue: Leo Campus - Politecnico di Milano
Attendees: All members

- Finalizing the report
- Finalizing the material for the exam (renders, maintenance manual, user manual)
- Shooting video
- Editing video

## Meeting 20/06/2022

Time: 9:00-20:00
Venue: Leo Campus - Politecnico di Milano
Attendees: All members

- Finalizing the report
- Finalizing the user manual
- Soldering step down wires, broken the day before :)
- Pictures of the assembled robot, for the user manual
- Printing report and manuals
- Fixing problems with the ultrasonic sensor, which does not detects properly
- Fixing the breathing features, which is acting too slow
- Finalizing video (missing shoots, editing them)
- Grabbing a spritz to party

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